ANIMAL MODEL OF HUMAN DISEASE

Lepromatous Leprosy

Animal Model: Experimental Lepromatous Leprosy in Nine-Banded Armadillos (*Dasypus novemcinctus* Linn)

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The nine-banded armadillo (*Dasypus novemcinctus* Linn)[1] (Figure 1) is one of approximately 20 species of armadillos comprising several genera. They belong to the Edentata. *D novemcinctus* ranges from Central Argentina through Central America, Mexico, the Gulf States, and northward into Oklahoma, Arkansas, and Georgia.

Among the characteristics which make this animal a useful research model for lepromatous leprosy are a) low body temperature (32 to 35 C), b) regular production of monozygotic quadruplet young, and c) a long life-span (estimated to be 15 years). Other biologic characteristics are a) delayed (14 to 16 weeks) implantation period of the blastocyst, b) gestation period of approximately 9 months, c) ability to build up an oxygen debt, and d) occasional variability in band numbers.

Pathologic Features

Forty percent or more of nine-banded armadillos of Louisiana, when inoculated intradermally, subcutaneously, or intravenously with a suspension of *Mycobacterium leprae*, develop a disseminated infection after 15

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to 34 months that histopathologically closely resembles lepromatous leprosy in humans.[2,3]

In human lepromatous leprosy the bacilli multiply prolifically within macrophages (histiocytes) (Figures 2 and 3) in tissues where the temperature ranges are comparable to the body temperature of the nine-banded armadillo. Lepromatous leprosy in humans, in sharp contrast to tuberculoid leprosy, shows no evidence of cell-mediated immunity to *M leprae*.

Similarities

The nine-banded armadillo infected with *M leprae*, as in human lepromatous leprosy, shows no cellular immunity against the bacilli. In both humans and armadillos, clusters or masses of the infected macrophages (histiocytes) cause lesions in the skin, dermal nerves, large nerves of the extremities, nose, and eyes.

Differences

Probably because of the animals' low body temperature, lepromatous disease in armadillos disseminates to tissues such as lung, heart, stomach, urinary bladder, spinal cord, and, occasionally, brain. These tumors are not sites of lesions in humans with lepromatous leprosy. The involvement of liver, spleen, and bone marrow is much greater in armadillos than in humans.

Usefulness of this Model

Experimental leprosy in the armadillo has made possible for the first time in the history of leprosy the collection of large quantities of *M leprae* for biochemical, enzymatic, and immunologic investigations. Lepromatous tissues from armadillos are now being sent to scientists, who, in collaboration with the World Health Organization, are carrying out basic studies on the leprosy bacilli.[4]

Lepromins prepared from lepromatous tissue of armadillos and tested intracutaneously in lepromatous and tuberculoid patients give reactions that correspond to those following injection of lepromins from human lepromas.[5] Adequate supplies of armadillo lepromin can now be made available to leprologists.

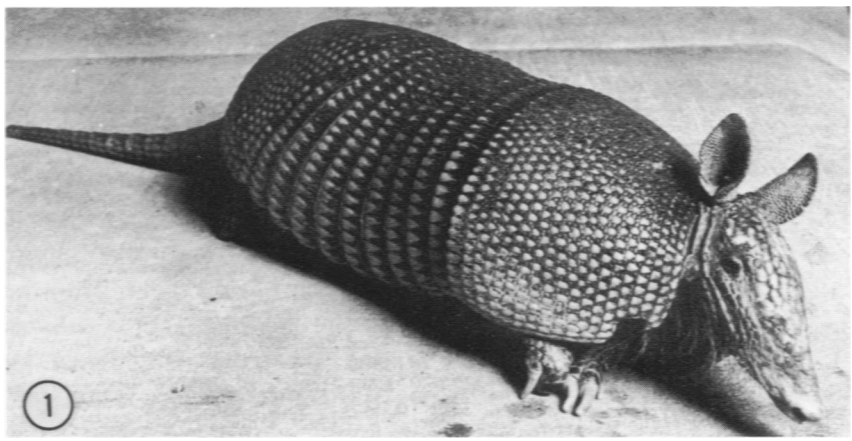
An armadillo with disseminated infection can repeatedly provide viable *M leprae* for microbiologists who are attempting to cultivate *M leprae*.

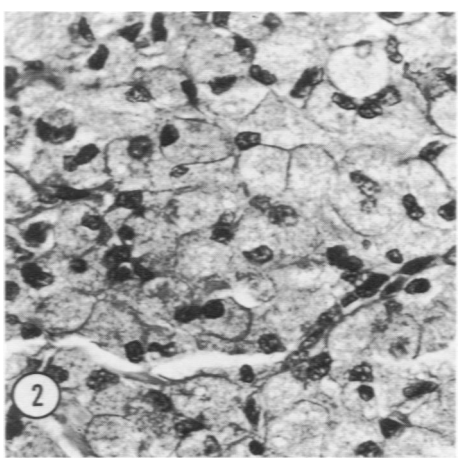
The nine-banded armadillo with disseminated lepromatous leprosy should be an excellent model for observing the direct action of drugs on *M leprae* because in this animal there is no demonstrable cellular reaction to the bacillus; however, scientists doing research in chemotherapy have not reported using this model in testing drugs.

Although the nine-banded armadillo has been bred in captivity only occasionally, pregnant females usually will deliver and raise their young after adjusting to captivity. The availability of monozygous quadruplets provides opportunities for controlled experiments in therapy and vaccine testing and for studies in pathogenesis of lepromatous leprosy.

Availability

Nine-banded armadillos are available in abundance in many of the Gulf States. In captivity they adapt slowly to and later thrive on a diet of dog or





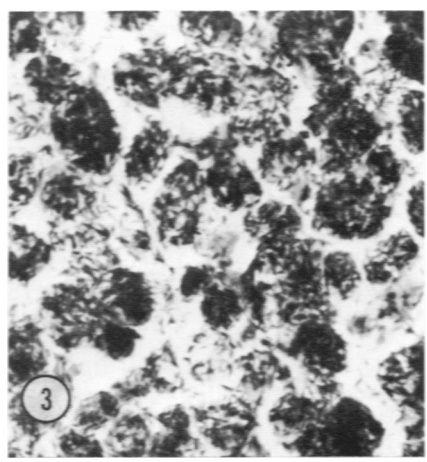


Figure 1—Nine-banded armadillo *(Dasypus novemcinctus)*. This armadillo was sent from the Gulf South Research Institute to the National Institute of Medical Research, London, demonstrating that research on armadillos can be done in laboratories with access to international air lines. (Photo courtesy of Dr. R. J. W. Rees) **Figure 2**—Early stage of foamy histiocytes ("lepra cells") in deep skin nodule of an armadillo inoculated intravenously with a suspension of *M leprae* 26 months before autopsy. (AFIP 73-7544) (H&E, × 395) **Figure 3**—Section similar to that shown in **Figure 2**, stained by the Fite-Faraco acid-fast method and photographed with a green filter. Note masses of bacilli in the histocytes. (AFIP 74-12218) (× 660)

cat chow supplemented with vitamins and minerals. They have been successfully transported by commercial airlines and maintained in laboratories in the northern United States and other countries (Figure 1).

Successful attempts to obtain a disseminated lepromatous disease in the nine-banded armdillo of South America have not been reported. A naturally acquired leprosy-like disease has been found in some recently captured armadillos in Louisiana.[6]

Other Susceptible Armadillo Species

Dr. Jacinto Convit, Director of the Instituto Nacional de Dermatologia, Caracas, Venezuela, and his associate, Mrs. M. E. Pinardi, have found the *D sabanicola* susceptible[7] to lepromatous leprosy. This animal, which is much smaller and more docile than *D novemcinctus*, would be an excellent laboratory model, but because it only lives in the high plains regions of Venezuela and Colombia, the numbers available are not yet adequate for comprehensive chemotherapy studies.

Two *D hybridus* from Argentina were inoculated at the Gulf South Research Institute with a suspension of *M leprae*. One was killed 24 months after inoculation and an autopsy was performed.[8] There was severe disseminated lepromatous disease that histopathologically was identical to that seen in the nine-banded armadillos which had been similarly inoculated. The other animal was not infected. This species regularly produces 8 to 16 monozygous young, but it is hyperactive and more difficult to handle than *D novemcinctus*.

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